ON THE ARTIFICIAL INDUCTION OF CONVULSIVE SEIZURES.

By FRANCIS X. DERCUM, M.D., PH.D.,
INSTRUCTOR OF NERVOUS DISEASES, UNIVERSITY OF PENNSYLVANIA;
AND
ANDREW J. PARKER, M.D., PH.D.,
PROFESSOR OF ZOÖLOGY, UNIVERSITY OF PENNSYLVANIA.

THE observations upon which these experiments are founded were first suggested by certain phenomena noticed during experiments upon table-tipping. Several years ago, in association with Dr. B. F. Lautenbach, formerly of the University of Pennsylvania, and Professor Elihu Thomson, formerly of the Central High School, we conducted a series of experiments to analyze more thoroughly the exact nature of certain convulsive seizures which were brought prominently to our notice during the progress of these experiments.

We present an account of these seizures which may be induced at will. This state differs widely from that of hypnotism, having but few factors in common with it. Heidenhain, it is true, occasionally noticed convulsive movements in his subjects, but these were always associated with the hypnotic state; that is, there was always present more or less modification of consciousness. Richer, also, in his investigations at the Salpêtrière, noticed certain epileptoid phenomena in connection with the state

of lethargy. These may bear some relation to our own observations. He describes them as follows: "At the beginning of the sleep, whatever method was employed for producing it, we have almost always observed in our patients some epileptoid phenomena: slight rigidity of the members, movements of deglutition, 'bruit pharyngien,' whistling inspiration, froth at the mouth."

Our own experiments were performed by subjecting one or a group of muscles to a constant and precise effort, the attention being at the same time concentrated upon some train of thought. The position we most frequently adopted was the following: The subject being seated, the tips of the fingers of one or both hands were so placed upon the surface of a table as to give merely a delicate sense of contact; *i. e.*, the fingers were *not allowed to rest* upon the table, but were maintained, by a constant muscular effort, *barely in contact* with it. Any other position involving a like effort of constant muscular adjustment was found to be equally efficient. Any one object in the room was now selected, and the mind fixed upon it, or some subject of thought was taken up and unswervingly followed.

After the lapse of a variable period of time, extending from a few minutes to an hour, and depending upon individual peculiarities to be noted, *tremors* commenced in the hands. These tremors became rapidly magnified into rapid movements of great extent, sometimes to and fro, sometimes irregular. If the experiment was now continued, the muscles of the arms, shoulders, back, buttocks, and legs, became successively affected, and the subject was frequently thrown violently to the ground in a strong general convulsion. The muscular contractions frequently became tonic, so that opisthotonus, emprosthotonus, and the most bizarre contortions were produced in various degrees.

The muscles of expression and those of respiration were

frequently affected along with the others. Wild gasps, distressing sobs, shrieks, and discordant cries were often produced. Immoderate laughter and crying, the latter often accompanied by an outflow of tears, were likewise observed, and, strange as it may seem, the corresponding emotions were either not present at all—certainly not in ourselves—or suggested to the subject in but a faint degree.

Seizures equalling in violence a general convulsion were by no means induced in all subjects, and were generally the result of experiments repeated many times during the same evening. It should be observed that the more frequently the experiments were performed the more readily the seizures were brought on, and, other things equal, with successively increasing intensity. In ourselves, after experimenting for several weeks in succession, the convulsions were induced with such alarming ease, it was thought advisable to desist for a long time.

An analysis of our observations leads to the following results:

In the first place, *no disturbances of sensation* were at any time present. Especial attention was paid to sensory phenomena, but none were at any time observed. It is important to bear this in mind.

Disturbances of *motion* constituted the prominent feature of the state. They consisted of movements involving one or more limbs or the entire body, and were produced by clonic spasms of the muscles, which, in their turn, were frequently followed by tonic contractions.

Whenever the respiratory and laryngeal muscles were involved, disturbances of *respiration* and *phonation* were present. The breathing at such times was generally spasmodic, and automatic cries were uttered. The involvement of the diaphragm was especially noticed in one of ourselves.

In the severe seizures, the *circulatory apparatus* was pro-

foundly affected. The pulse became rapid, and in extreme convulsions became intermittent. In some instances, when the paroxysm was at its height (*i. e.*, intense clonic or tetanic action of all the muscles), a momentary arrest of the heart's action was noticed. Now and then auscultation of the heart at the end of a severe seizure revealed a bruit which, though of short duration, reminded one of a similar sound sometimes heard in chorea.

Regarding the *secretions*, with the exception of a flow of tears and occasional profuse perspirations, no other symptoms were noticed, except in two instances. In these, after the persistent induction of severe seizures for several hours, large quantities of pale urine were voided. As these phenomena were not observed as usual concomitants of the condition, it may be well not to lay too much stress upon them; yet their occasional occurrence is in the highest degree suggestive. Perhaps, had the experiments in all cases been carried to the same extent, the same results would have been observed.

The *reflexes* were distinctly exaggerated. This was readily demonstrated when the experiment had been carried on sufficiently long to produce decided convulsive movements of the arms and legs. If a subject was examined immediately after a seizure, the patellar reflex was almost always found to be increased. At this time tonic contractions of muscles could easily be induced, for example, by forcible flexion of a limb, though these contractions would be of *short* duration. These observations are in harmony with those of Heidenhain, who speaks of increased reflex irritability and tonic spasm of the muscles as being observed in his hypnotic experiments. Richer, in one of the forms of lethargy induced by him, noticed a similar condition. Our own observations differ from those of both of these investigators, in that these phenomena are present for but a short

time. The knee reflex, for instance, resumes its normal character within a few moments after the cessation of a convulsion. It seems as though this short period of reflex irritability was but the result of an exalted functional activity of the cord preserved for a few moments after the convulsion itself had ceased.

As regards the *psychic* phenomena, there was, in the first place, *no modification of consciousness* ever observed. There was, however, a *progressive abeyance* or *paresis of the will.* That is, although the mild forms of the state, such as tremor or slight convulsive movements, could be controlled by a slight effort, each successive seizure required a stronger or more intense exertion of the will. Finally, all control over the seizure was lost. In a general convulsion or severe tetanic condition, the will was absolutely powerless.

We observed, also, another curious fact. When one of a number of subjects was affected, one or more of the others would shortly follow. This occurred even when the latter were not complying with the terms of the experiment, provided only that they had previously been affected. This state, therefore, appears to be *contagious*, very much as a yawn is contagious; probably by unconscious suggestion.

Regarding temperament, it was noticed that persons with a neurotic element in their composition were more readily affected than those who were dull and heavy. Those, also, who were unable to concentrate their attention for any length of time proved poor subjects, while others, again, seemed utterly incapable of maintaining a *delicate* contact with the table. They invariably, after a few moments, allowed the fingers to *rest* upon the table. Of course, under these circumstances, no tremor or convulsive movements followed.

Strong and muscular men, other things being equal, were found to be affected less readily than weak men.

Another remarkable fact noticed was, that nitrite of amyl appeared to arrest the convulsive seizures at once. At least this was the result obtained in the few trials that were made with it. Particularly was this action noticed in reference to the momentary interference of the heart's action. Richer speaks highly of its action in hystero-epilepsy, and this fact, coupled with its action in true epilepsy makes the results we obtained doubly suggestive.

Our experiments were conducted, not only upon ourselves and immediate relatives, but upon a large number of friends, both male and female, though upon the latter, for obvious reasons, the experiments were never pushed to extreme degrees.

There can be no doubt that the state described in this communication bears a distinct relation to hysteria, if not to convulsive seizures in general. No doubt it bears a distinct relation to many of the phenomena presented by certain religious sects, as the "Shakers" and "Jerkers." No doubt it explains the antics of the supposed victims of the Salem witches, the Tarentism of Italy, the epidemic chorea of Germany, the dancing Dervishes, the contortions of the Convulsionaires, and a hundred other things too numerous to mention. Possibly, and very probably, it is one of the atoms of truth around which are collected the follies of spiritualism and table-tipping. It is one of those curious states which has been too little, if at all, studied.

Having now in a general way given an account of these convulsive seizures, we now venture to propose an explanation of them. In order that we may be thoroughly understood, it will be necessary to consider a few general points in relation to the mode of origin of the neuro-muscular system; principles deduced from comparative anatomy and embryology.

Animal motions are a resultant of certain changes taking

place in protoplasm. In the simplest forms of animals these motions take place in an apparently indefinite manner. Thus, in the amœba, motion appears as a mere indefinite ebb and flow, aparently without fixity, apparently without system, nor are they due to any visible apparatus.

As we advance, however, we find that this original indefiniteness of motion is succeeded by fixity and definiteness. At first we find merely fixity as regards direction of flow, as in the pseudopodic rays of the Foraminifera and Radiolaria. Eventually this mere ebb and flow is succeeded by definite motor appendages, as cilia, etc., in the infusoria; or the body itself may, as a whole, take on a pulsatory action to move it from place to place.

As we advance through the animal kingdom, however, we find a special apparatus developing, known as the neuro-muscular system. In its earliest condition it appears as the so-called neuro-muscular cells of Kleinberg, as found in hydra. These cells are simply irritable and contractile. As differentiation proceeds, we find this system separating into two portions, one an irritable portion, the other a contractile portion, known respectively as nerves and muscles. Now, Herbert Spencer has shown, in one of his works, that the evolution of a neuro-muscular system is a necessary consequence of certain dynamical laws. Given a homogeneous animal, exposed to all the forces of its environment, there must, as a necessity, follow, that in the animal certain lines of least resistance to the passage of ingoing and outgoing motions must be formed. The nervous system, therefore, represents, *primitively*, merely specialized tracts for the transmission of motion. With increased specialization many other functions appear. Not only must the nervous system, therefore, be a means of correlating the animal with its environment, but it must also have the function of correlating the various parts of the animal body.

It would appear, therefore, that constant adjustments and readjustments are taking place; and further, as we shall see, these changes are rhythmical. Again, we are obliged to refer to those most remarkable inductions of Spencer, one of which is the universality of the rhythm of motion. Without going into a detailed account of the causes operating to produce this universal rhythm, we may safely assert that there continually flows through the whole nervous system of every living animal a constant rhythmical interchange of motion between all parts of the body; and this is what might, perhaps, be called *nervous equilibration.*

Leaving out of consideration the lower animals, with which, at present, we have no concern, we may at once pass to the consideration of the neuro-muscular relations, as they exist in the higher animals, of which we shall take man as a type. In man we find a central nervous system, from which we have passing to and from all the parts of the body nervous tracks. These end in motor organs, glands, etc. In studying the relations of the motor organs to each other, we find that they may be divided into two classes, one group producing motion in a particular direction, whilst the function of the other is to antagonize this action, and bring any part of the body back into the particular condition from which it was removed. During these actions and reactions of groups of muscles, flexion, extension, pronation, supination, etc., we find that the action is not a *continuous* one. The particular muscle or muscles are thrown into a series of rhythmical contractions. These contractions have been recognized and described, for a long time, under the name of the muscular susurrus.

Perhaps considerations of this kind may appear somewhat irrelevant, but we think it will be found that these rhythmical functions of the nervous system lie at the foundation of an explanation of these artificially induced convulsive seizures, if not in all others.

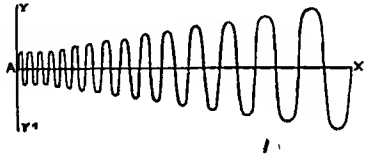
We have already described the methods by means of which these artificial seizures may be brought about. Now let us consider under what particular conditions the neuro-muscular apparatus is placed during experiments of this character. Thus far we have considered the action of the neuro-muscular system as a mere ebb and flow of motion, without respect to any controlling agency. In man, we find an element entering which we have thus far not discussed, viz., the will. Undoubtedly the will, within certain limits, modifies and controls the actions of the muscular system. How far the will is able to modify and control is, we think, tested by these experiments.

A person places his hands, or perhaps any other part of his body, in a position of effort. According to the view advanced above, what must happen? Evidently, as we have already shown, there must be a rhythmical series of motions taking place between the antagonistic groups of muscles, because the rhythms of these cannot be synchronous.

At first the will restrains any tendency to marked vibration in the part; but, as we already stated, let the mind be directed into any particular channel of thought, which simply means concentration, and as a result a loss of intensity in will-power as regards other channels. Hence in a case where antagonistic groups of muscles in a state of strain are left, as it were, to themselves, the restraining influence being either diminished or else held almost in abeyance, we find as a result of the exhaustion of neuro-muscular protoplasm that a disturbance must take place. This disturbance must necessarily be rhythmical. Hence we have a rhythmical motion of the part as shown by increased tremor. The action continuing, the tremor is succeeded by to-and-fro movements. At first it affects only the parts under strain, but this disturbance, which might perhaps be considered a purely local phenomenon,

spreads through the mobile channels of the neuro-muscular apparatus and affects it as a whole. Thus we see that beginning with tremor of the hand, we finally have the flexors and extensors of the forearm thrown into violent clonic contractions. Next the muscles of the arm and shoulder are involved. At last, such a violent explosion takes place that the neck, the back, the legs, the diaphragm, the heart even, are affected. A small cause is thus apparently able to produce the most profound results.

We might, perhaps, be permitted to express these results graphically.



Let A X = time of experiment, and A Y and A Y' = amplitude of rhythmical movements.

At the commencement of the experiment the curves express the normal rhythm between the antagonistic muscles, which is the resultant of the composition of the normal rhythmical motions of the individual muscles in the opposed groups.

As the time A X increases, we find the amplitude of the rhythmical vibration steadily increasing up to the limits of exhaustion.

In this brief communication we have simply attempted to present a group of phenomena, produced artificially, which seem closely related to certain nervous affections.